Utility of MR Angiography in the Identification of Prostatic Artery Origin Prior to Prostatic Artery Embolization

Alexander Y. Kim, MD, David H. Field, MD, MS, Danielle DeMulder, MD, James Spies, MD, MPH, and Pranay Krishnan, MD

ABSTRACT

In 17 patients who underwent prostate artery embolization for treatment of lower urinary tract symptoms, the accuracy of preprocedural magnetic resonance (MR) angiography was retrospectively compared with intraprocedural digital subtraction angiography (DSA) in the identification of prostatic artery origin. Of 34 vessels, 26 MR angiography identified origins (76.5%) were confirmed by DSA at the time of embolization. Although image postprocessing is required, the ability of MR angiography to accurately identify prostatic artery origins prior to embolization is useful in treatment planning and can obviate the need for separate computed tomographic angiography, thus reducing both radiation dose and time demand on patients.

ABBREVIATIONS

ADC = apparent diffusion coefficient, CPR = curved planar reformat, DS = digital subtraction, MIP = maximum intensity projection, MPR = multiplanar, PAE = prostate artery embolization

INTRODUCTION

Multiple retrospective and prospective studies have demonstrated that prostate artery embolization can significantly improve lower urinary tract symptoms from benign prostatic hypertrophy (1–4). Although akin to uterine artery embolization, prostate artery embolization (PAE) is made technically more difficult by the smaller caliber of the prostatic arteries and their more variable origin in comparison with uterine arteries. Multiple vessels, including the superior and inferior vesical arteries and the superior, middle, and inferior rectal arteries, can be confused with the prostatic arteries on angiography (5,6).

The challenges posed by the anatomy of the male pelvis make thorough treatment planning crucial. Although some groups advocate the use of computed tomographic (CT) angiography for treatment planning (6), this increases the burden of time and radiation on patients, who may already undergo preprocedural magnetic resonance (MR) imaging of the prostate for the purposes of glandular assessment and volumetric measurement. In lieu of an additional CT angiography, and MR angiography sequence was added to the existing pre-embolization MR imaging protocol to identify the origins of the prostatic arteries. The objective of this study was to retrospectively assess the ability of MR angiography to depict the origins of the prostatic arteries using intraprocedural digital subtraction (DS) angiography as the standard of reference.

MATERIALS AND METHODS

Health Insurance Portability and Accountability Act-compliant and institutional review board-approved retrospective analysis was performed on imaging obtained before and during prostate artery embolization in a single institution from January 2014 to December 2016.

Twenty-five patients underwent PAE during this time period. Six of these patients did not undergo preprocedural MRI/MRA due to patient refusal, scheduling error, or procedural urgency. Two patients had technically suboptimal MR imaging/MR angiography and were excluded, one due

From the Department of Radiology, Medstar Georgetown University Hospital, Washington, DC, 20007. Received February 12, 2016; final revision received November 2, 2017; accepted November 3, 2017. Address correspondence to A.Y.K.; E-mail: alexander.y.kim@gunet.georgetown.edu

A.Y.K. receives grants and personal fees from Surefire Medical (Westminster, Colorado) and personal fees from Sirtex Medical (New South Wales, Australia) and Bayer (Leverkusen, Germany). None of the other authors have identified a conflict of interest.

From the 2015 SIR Annual Meeting.

Table E1 is available online at *www.jvir.org*.

© SIR, 2017

J Vasc Interv Radiol 2018; 29:307–310

https://doi.org/10.1016/j.jvir.2017.11.001

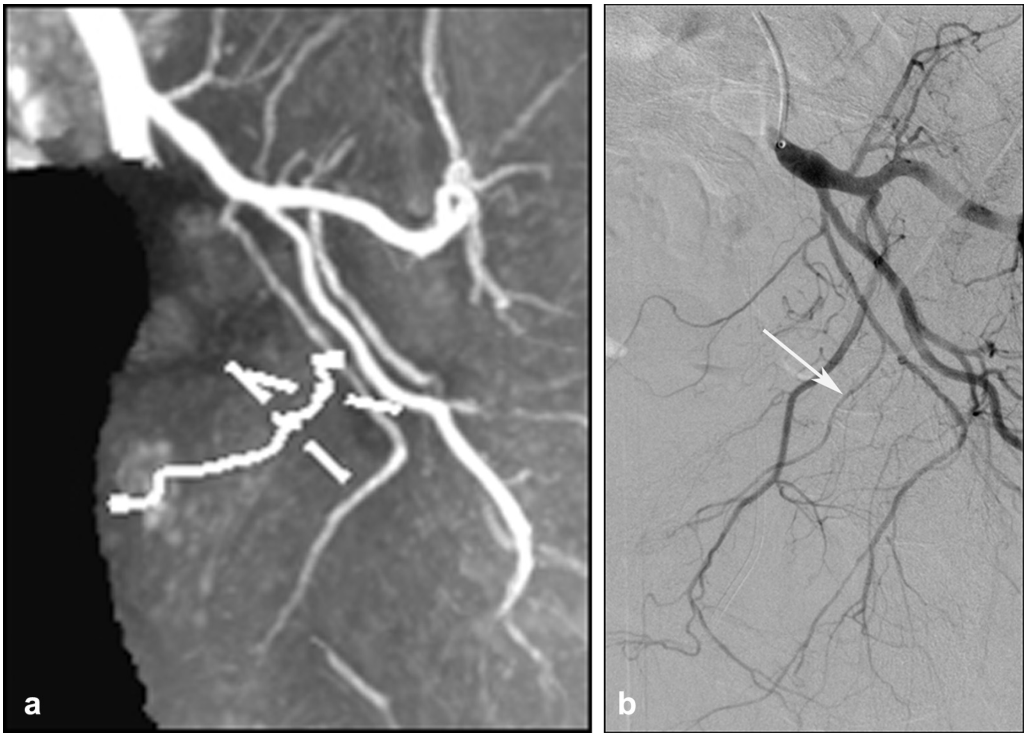

Figure 1. **(a)** MIP of MR angiography with line superimposed on left prostate artery originating from the left internal pudendal artery. **(b)** Corresponding DS angiography of the left prostate artery (arrow) in the same patient.

to poor timing of contrast bolus; the other due to incomplete visualization of the prostate in the field of view.

Pre-PAE MR imaging was performed on a Siemens Verio 3.0 Tesla magnet (Munich, Germany) using a phased-array coil to produce multiparametric sequences that included multiplanar 2-dimensional (2D) rapid acquisition with relaxation enhancement (RARE), 3-dimensional (3D) sampling perfection with application-optimized contrasts using different flip-angle evolution (SPACE) T2-weighted images, and diffusion-weighted imaging with apparent diffusion coefficient (ADC) map. After the administration of .1 mL/kg Gadovist (gadobutrol; Bayer, Ontario, Canada) injected at 1.5 mL/sec, MR angiography using 3D volumetric interpolated spoiled gradient echo was obtained with the following parameters: field of view (FOV) extending from the aortic bifurcation to the common femoral arteries with 2-mm slice thickness; matrix 256 x 179; TR 4.3; TE 2.45; and acquisition time, 20 seconds. FOV for the remainder of sequences was set to encompass the entire prostate gland and seminal vesicles. Prostate glandular volume was calculated via 3D semi-automated segmentation (DynaCAD Prostate; Invivo, Gainesville, Florida).

Two board-certified abdominal radiologists (P.K., with 6 years of vascular imaging experience and D.D., with 2 years of vascular imaging experience) were blinded to findings of intraprocedural DS angiography. Each radiologist independently evaluated all MR angiography images and created two sets of postprocessed images on a workstation (Aquarius Intuition; TeraRecon Inc., Foster City, California): rotational maximum intensity projections (MIPs) of the internal iliac arteries and its branches and curved planar reformats (CPRs) of the prostate artery derived from axial and coronal multiplanar (MPR) images, created by tracing the vessel back to the internal iliac artery from the prostate (Figs 1a, b). The origin of the prostatic artery was identified in relation to the anterior division of the internal iliac (i.e., as the first or second branch of the anterior division) or as a branch of the internal pudendal artery (Figs 2a–f).

Prostate artery embolization was performed on a Siemens Artis Q (Munich, Germany). Two board-certified interventional radiologists with 5 years (A.K.) and 31 years of experience (J.S.) performed all of the procedures. Bilateral common femoral artery access was obtained in all patients. Both internal iliac arteries were selected with a Cobra (AngioDynamics, Latham, New York) or Rim (Cook, Bloomington, Indiana) catheter. If the prostatic artery origin could not be conclusively identified on initial DS angiography, cone-beam CT images were obtained with the catheter positioned in the internal iliac artery or the anterior division of the internal iliac artery for confirmatory purposes. The prostatic arteries were subselected with a 2.4 Fr Progreat microcatheter (Terumo, Tokyo, Japan) and .016" Fathom wire (Boston Scientific, Marlborough, Massachusetts). Locations of the prostatic artery origins identified by MR angiography were retrospectively compared with origins confirmed angiographically to assess the accuracy of MR angiography in detecting the origin of the prostatic artery.

RESULTS

A total of 17 patients were evaluated both with MR angiography and angiography. Of the 34 total prostatic arteries,

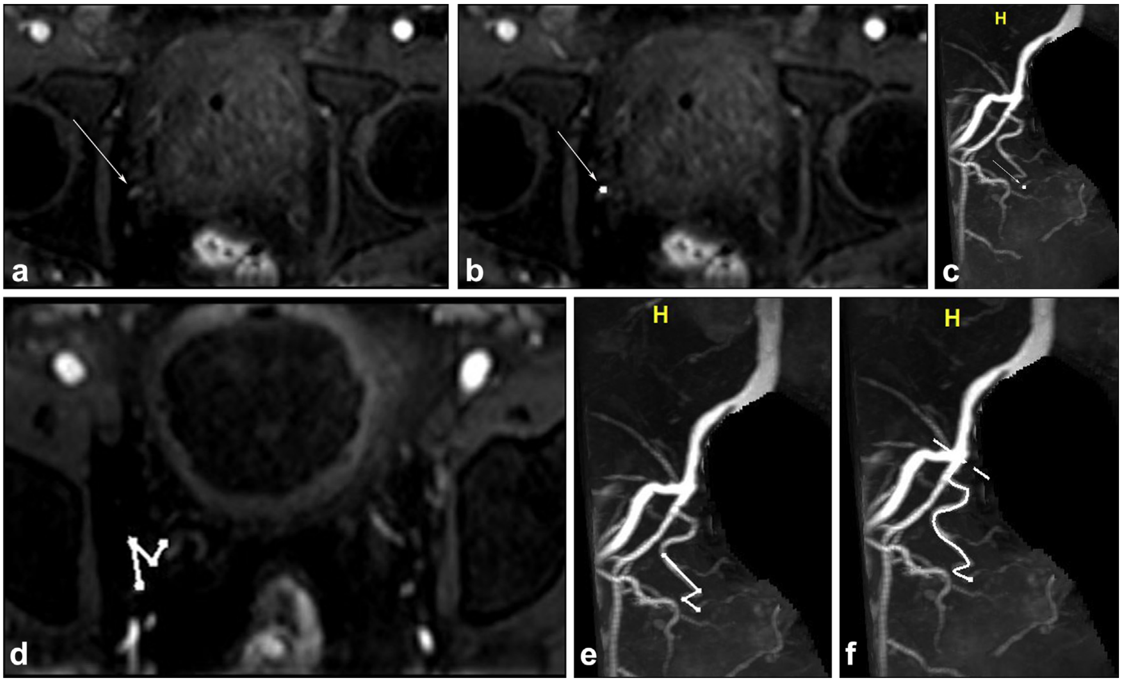

Figure 2. **(a)** Axial MPR of prostate MR angiography demonstrating right prostate artery (arrow) where it enters the prostate (marked with a white dot in [**b**]). **(c)** Corresponding dot superimposed on rotational MIP of the internal iliac artery (arrow). **(d)** Right prostate artery identified at 4 separate points connected by a solid line that overlies the length of the prostate artery between the points **(e)**. Same 4 points of the prostate artery and connecting solid line superimposed on rotational MIP **(f)** Vessel traced back to its origin from the internal iliac artery on MIP.

MR angiography correctly identified the origin of 27 vessels (79.4%); of the 17 total patients, MR angiography correctly determined the bilateral prostatic artery origin in 13 (76.5%) (**Table E1** [available online at *www.jvir.org*]). In all patients, the origin of the prostatic artery could not be identified by either reader on rotational internal iliac artery MIPs alone since required slab thickness precluded visualization of the small-caliber prostatic arteries (**Fig 3a**). By producing axial and coronal MPR and CPR, however, both readers were able to identify the origin of the right prostatic artery in all 17 patients and the left prostatic artery in 14 of the 17 patients. Neither reader was able to identify the origin

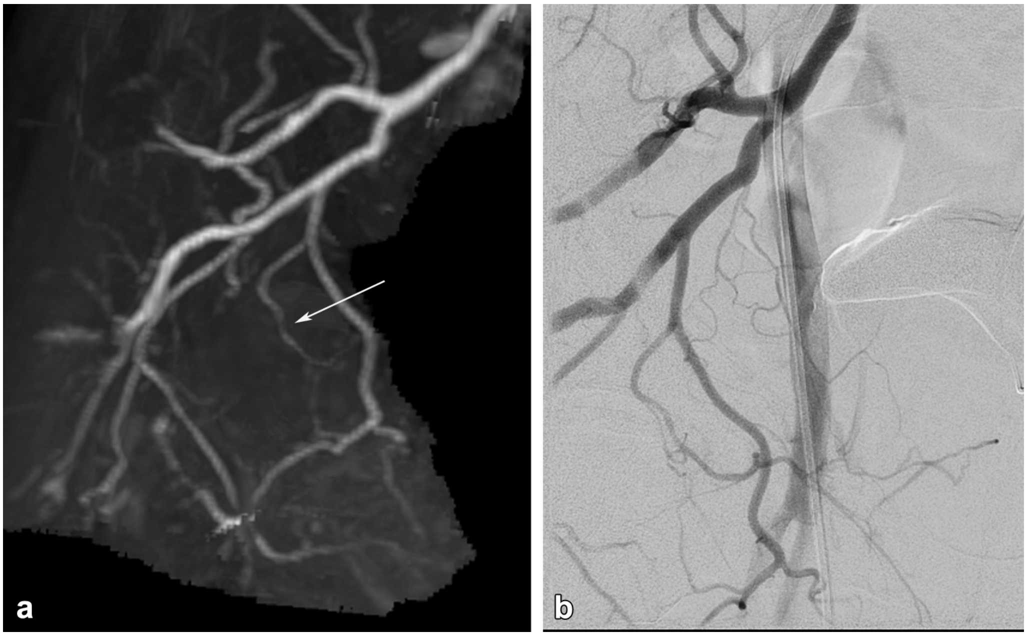

Figure 3. **(a)** MIP of the internal iliac artery and branches. The prostatic artery (arrow) is not identifiable on this image alone, since it must be traced in retrograde fashion to its origin by the creation of curved planar reformats. **(b)** Corresponding DS angiography of the internal iliac artery and its branches, including the prostatic artery, in the same patient.

of the left prostatic artery in the same 3 patients; 2 of these were later determined to arise as the second branch of the anterior division of the internal iliac artery, and 1 arose as the first branch. There was 100% agreement between the 2 MR angiography readers in identifying the origin of the 31 visualized prostatic arteries.

In these 31 vessels, DS angiography confirmed the location of the MR angiography-identified origin in 27 vessels (87%) (**Fig 3b**). The prostatic origin identified angiographically was different than that initially identified on MR angiography for 4 vessels—both right and left in 2 patients. On the right, 1 origin identified by MR angiography as the second branch of the anterior division of the internal iliac artery was seen on DS angiography to arise as a branch of the internal pudendal. The origin of the second misidentified prostatic artery on the right was angiographically determined to be the second branch of the anterior division of the internal iliac artery rather than the first. The same transposition of anterior division branches was discovered on 1 of the 2 misidentified prostatic arteries on the left, while the other misidentified artery was angiographically determined to be the first branch of the anterior division rather than the second. In 1 case, the left prostatic artery origin identified on MR angiography could not be conclusively identified on DS angiography.

DISCUSSION

Notoriously variable origin of the prostatic arteries makes angiographic identification challenging during PAE (7,8). While spatial resolution of MR angiography is inferior to that of CT angiography (9), the ability of MR imaging to provide accurate volumetric assessment and characterization of the gland makes it a superior choice for preprocedural evaluation compared with CT, which also exposes the patient to added radiation and carries risks of contrast-related renal toxicities (10). Postprocessed 3D images derived from MR angiography are well-suited for preprocedural planning and can be obtained with little additional time and expense. While the diminutive nature of the prostatic arteries makes rotational MIPs alone useless in identifying their origins or distinguishing them from rectal and vesical arteries, the prostatic arteries can be readily visualized on axial and coronal CPR/MPR. Multiplanar-reformatted MR angiography images allow identification of the prostate artery origin in relation to the internal iliac artery, and the origin identified by MR angiography is confirmed angiographically in the vast majority of cases. The 1 vessel identified on MR angiography but not visualized on DS angiography may have been angiographically inapparent due to catheter-induced spasm or the presence of retrograde filling on MR angiography not appreciable on real-time DS angiography. The few instances of misidentification may have been related to spatial resolution limitations and diminutive nature of the vessel.

The accuracy of prostatic artery identification on MR angiography also is user dependent; that is, it is solely dependent on the accuracy of the manually drawn CPR centerline during MPR creation. It is possible that misidentification of prostatic artery origins may have been due to incorrect drawing of the centerline. While 100% concordance in interpretations between readers with subspecialized training in vascular imaging is reassuring, a larger series with multiple MR angiography readers is necessary to validate this method of vessel depiction as a viable means of preprocedural planning.

Multiparametric MR imaging has a clear role in assessment of the prostate, both prior to and after embolization. It allows for visualization of benign glandular and stromal transition zone nodules, can be used to measure glandular volume, and can provide an overall assessment of glandular vascularity. MR imaging is well suited for pre-embolization planning and follow-up, since it is capable of consistent, reproducible measurement of parenchymal vascularity and glandular volume before and after treatment. The ability of prostate MR imaging to detect malignancy also offers significant ancillary benefit (11).

As more patients seek embolization rather than surgical options, reliable and efficient pretreatment imaging protocols will become increasingly important. The addition of MR angiography to existing prostate MR imaging protocols offers the interventional radiologist dependable and valuable information that decreases procedural uncertainty while alleviating the radiation, time, and expense associated with standard pre-embolization CT angiography.

REFERENCES

1. Uflacker A, Haskal ZJ, Bilhim T, Patrie J, Huber T, Pisco JM. Meta-analysis of prostatic artery embolization for benign prostatic hyperplasia. J Vasc Interv Radiol 2016; 27:1686–1697.e8.
2. Pisco JM, Bilhim T, Pinheiro LC, et al. Medium- and long-term outcome of prostate artery embolization for patients with benign prostatic hyperplasia: results in 630 patients. J Vasc Interv Radiol 2016; 27:1115–1122.
3. Carnevale FC, da Motta-Leal-Filho JM, Antunes AA, et al. Quality of life and clinical symptom improvement support prostatic artery embolization for patients with acute urinary retention caused by benign prostatic hyperplasia. J Vasc Interv Radiol 2013; 24:535–542.
4. Jones P, Rai BP, Nair R, Somani BK. Current status of prostate artery embolization for lower urinary tract symptoms: review of world literature. Urology 2015; 86:676–681.
5. Garcia-Monaco R, Garategui L, Kizilevsky N, Peralta O, Rodriguez P, Palacios-Jaraquemada J. Human cadaveric specimen study of the prostatic arterial anatomy: implications for arterial embolization. J Vasc Interv Radiol 2014; 25:315–322.
6. Bilhim T, Tinto HR, Fernandes L, Martins Pisco J. Radiological anatomy of prostatic arteries. Tech Vasc Interv Radiol 2012; 15:276–285.
7. Isaacson AJ, Bhalakia N, Burke CT. Coil embolization to redirect embolic flow during prostatic artery embolization. J Vasc Interv Radiol 2015; 26: 768–770.
8. Bhatia S, Sinha V, Bordegaray M, Kably I, Harward S, Narayanan G. Role of coil embolization during prostatic artery embolization: incidence, indications, and safety profile. J Vasc Interv Radiol 2017; 28:656–664.e3.
9. Lin E, Alessio A. What are the basic concepts of temporal, contrast, and spatial resolution in cardiac CT? J Cardiovasc Comput Tomogr 2009; 3: 403–408.
10. Garvey B, Türkbey B, Truong H, Bernardo M, Periaswamy S, Choyke PL. Clinical value of prostate segmentation and volume determination on MRI in benign prostatic hyperplasia. Diagn Interv Radiol Ank Turk 2014; 20: 229–233.
11. Ahmed HU, El-Shater Bosaily A, Brown LC, et al. Diagnostic accuracy of multi-parametric MRI and TRUS biopsy in prostate cancer (PROMIS): a paired validating confirmatory study. Lancet 2017; 389:815–822.

Table E1. Prostate Artery Vessel Origins in 34 Pelvic Sides as Identified on MR Angiography versus DS Angiography

Patient	Right MR Angiography	Right DS Angiography
1	1st branch of anterior division	1st branch of anterior division
2	1st branch of anterior division	1st branch of anterior division
3	Branch of proximal internal iliac	Branch of proximal internal iliac
4	Branch of internal pudendal artery	Branch of internal pudendal artery
5	Branch of proximal internal iliac	Branch of proximal internal iliac
6	2nd branch of anterior division	2nd branch of anterior division
7	2nd branch of anterior division	2nd branch of anterior division
8	1st branch of anterior division	1st branch anterior division
9	1st branch of anterior division	1st branch anterior division
10	Branch of internal pudendal artery	Branch of internal pudendal artery
11	1st branch of anterior division	1st branch of anterior division
12	1st branch of anterior division	2nd branch of anterior division*
13	2nd branch of anterior division	2nd branch of anterior division
14	2nd branch of anterior division	Branch of internal pudendal artery*
15	1st branch of anterior division	1st branch of anterior division
16	1st branch of anterior division	1st branch of anterior division
17	1st branch of anterior division	1st branch of anterior division
	Left MR Angiography	**Left DS Angiography**
1	1st branch of anterior division	1st branch of anterior division
2	1st branch of anterior division	1st branch of anterior division
3	1st branch of anterior division	Not identified†
4	Branch of internal pudendal artery	Branch of internal pudendal artery
5	1st branch of anterior division	1st branch of anterior division
6	Not visualized†	2nd branch of anterior division
7	Branch of internal pudendal artery	Branch of internal pudendal artery
8	1st branch anterior division	1st branch anterior division
9	Not visualized†	2nd branch of anterior division
10	Branch of internal pudendal artery	Branch of internal pudendal artery
11	1st branch of anterior division	1st branch of anterior division
12	1st branch of anterior division	2nd branch of anterior division*
13	1st branch of anterior division	1st branch of anterior division
14	2nd branch of anterior division	1st branch of anterior division*
15	Branch of internal pudendal artery	Branch of internal pudendal artery
16	1st branch of anterior division	1st branch of anterior division
17	Not visualized†	1st branch of anterior division

DS = digital subtraction.
*Discordant findings of PAE origins between DSA and MRA.
†Nonvisualization of vessel origin on MRA or DSA.